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MANNED MARS MISSION SCHEDULE REPORT

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ABSTRACT

This section contains the schedules for hardware for the initial manned Mars mission. The mission for the purpose of this report is determined to be a 1999 opposition mission and the vehicle hardware configuration for the mission is as depicted in Figure 1.

BACKGROUND

NASA has experienced phenomenal success in its brief history with the major programs of Saturn (I, IB, and V), Skylab, Shuttle, and Spacelab. Prior to the flight of a manned Mars mission, it is anticipated that the Space Station, Shuttle Derived Vehicle (SDV), and Orbital Transfer Vehicle (OTV) will have become operational. It is also anticipated that DOD will be well into the Strategic Defense Initiative (SDI) development and operation by the year 1999, and that NASA will have a large role in the development and operation of hardware for that system. Accepting the challenge for manned Mars missions will be one that NASA is equally qualified for and willing to assume.

During the late 1960's, NASA performed in-depth studies of various Mars missions. A large portion of the data generated as a result of those studies can be utilized for a future definition study for manned Mars missions. As mentioned earlier, the development of technology/hardware through these other programs will be of tremendous benefit through the reduction of development time and cost to the manned Mars program.

This paper attempts to cover all facets of the initial manned Mars mission for this particular launch vehicle configuration. The program begins with definition studies and continues with schedules for hardware necessary for reaching Mars and returning to Earth. Since hardware/software is the most tangible criteria from a scheduling standpoint, seven categories of hardware were selected for analysis. These categories are as follows: (1) Rocket Vehicles; (2) Spacecraft; (3) SDV-3R Payload Adapters; (4) Experiments; (5) LEO Assembly

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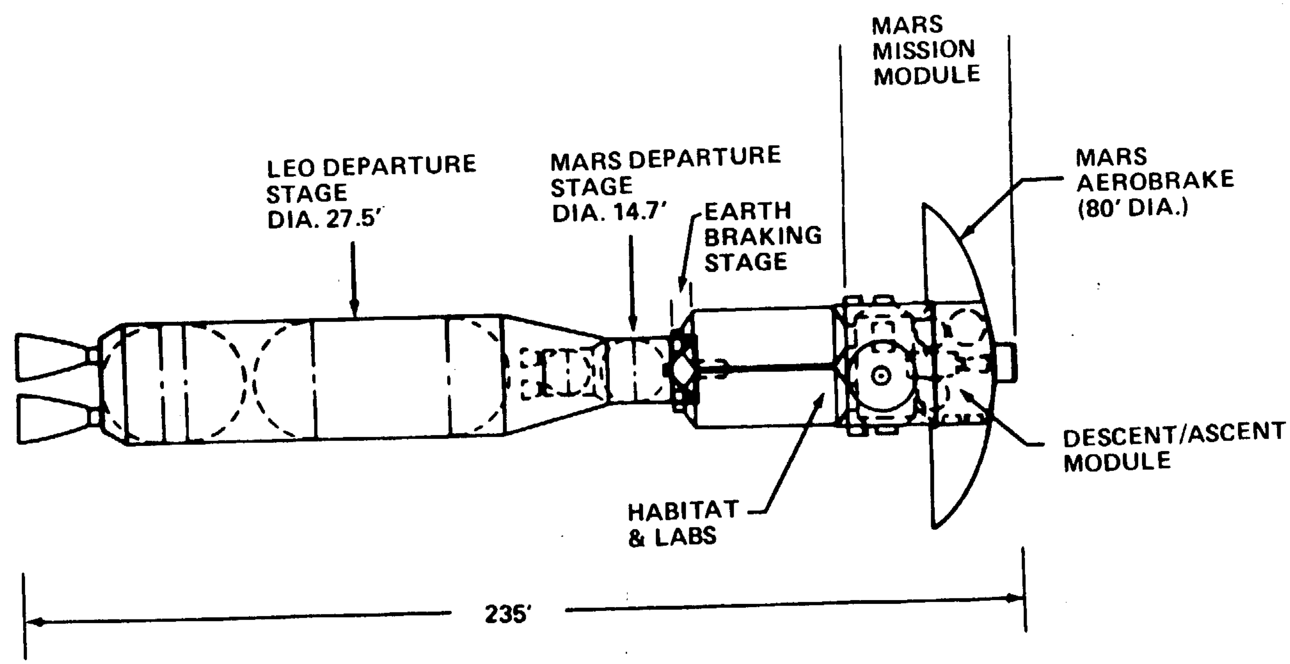
1999 OPPOSITION MANNED MARS MISSION AEROBRAKE OPTION



EARTH DEPARTURE VEHICLE

FIGURE 1

Equipment; (6) Training Hardware and Facilities; (7) Mission Control and Communications Network.

Launch site facilities were not covered, since it is assumed that these facilities will be in existence from other national space booster programs such as SDV, SDI, etc. In the time allocated for this study, schedule information for a large number of vehicle configurations was not developed nor would it have been desirable to do so at this time. Instead, one vehicle was selected that seemed most feasible to be developed by the 1997/1988 (start LEO operation 1997 and start Earth departure 1998) time period.

SCHEDULES

(Refer to Figures 2 through 8)

METHODOLOGY

Nine flights of the SDV-3R vehicle are required to place all hardware/equipment, including propellant into Low Earth Orbit (LEO). These flights will be scheduled as required to optimize the assembly at LEO. The SDV hardware to be recovered from these flights are the Propulsion/Avionics (PA) modules and the Solid Rocket Boosters (SRBs), however, there is insufficient time for these hardware items to be refurbished and reused for the remaining SDV-3R flights on the same manned Mars mission. An airplane will be leased to return the PA modules from the recovery site to the refurbishment site.

Five STS missions are planned for the crew during the manned Mars mission. Included are two assembly crew rotations required in LEO plus the placing of the flight crew into orbit and return. An OTV flight will be made available for rendezvousing with the manned Mars vehicle upon Earth return and transferring the crew to LEO to rendezvous with the Space Station or the Orbiter.

The power subsystem for the mission has not be selected. If a nuclear or isotope system is selected it will be imperative that early go-ahead be given for definition studies as these systems require very long lead times. (Refer to Table 1 for estimate of development time for various power systems.)

Orbital assembly of the space vehicle could require up to a year in duration, however, LEO assembly has not been totally assessed, therefore, this ample schedule cushion has been included. If this assembly is

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ROCKET VEHICLES

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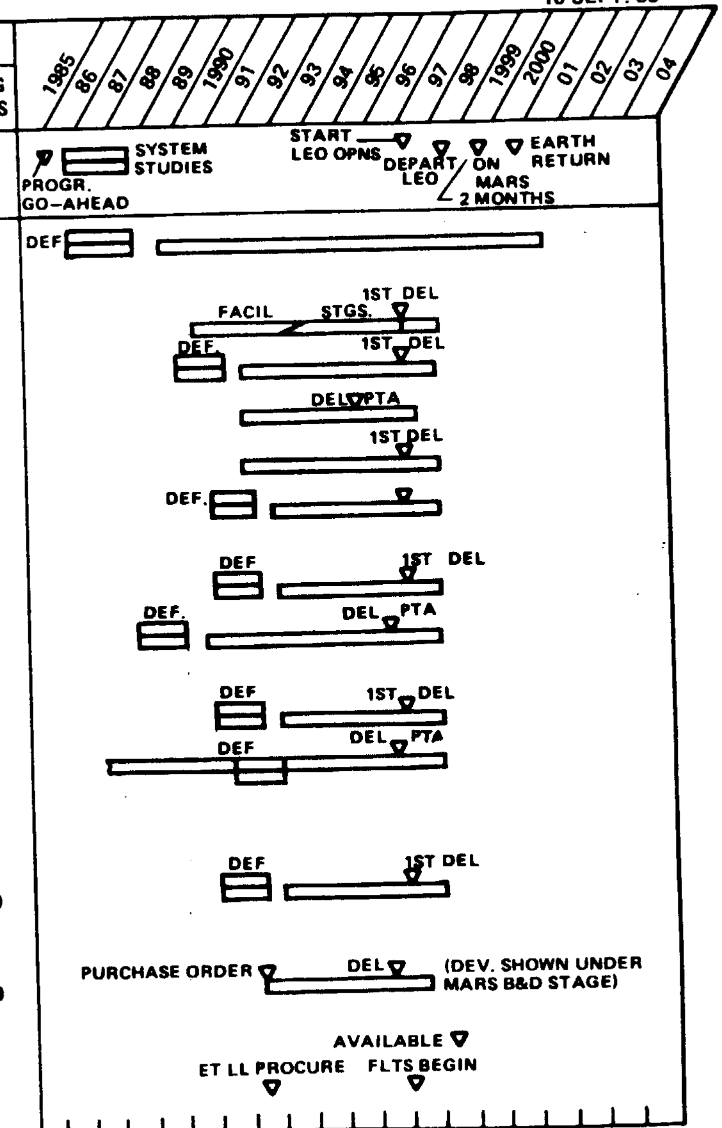
MAJOR HARDWARE ELEMENTS	HWD. QUANTITY: FLIGHT UNITS	GSE SETS	SOFT-WARE SETS	TESTS UNITS	TRNG UNITS
MAJOR MILESTONES					
● SYS ENGR & INTEGR					
● EARTH–TO–ORBIT VEH SDV–3R					
– ET	9	0	0	0	0
– P/A MODULE	9	3	3	2	0
● 3 STME'S	27	6	6	0	0
– SRB'S (DEVEL. EXIST)	18	6	0	0	0
– SHROUD	9	3	0	2	0
● LEO DEPARTURE STAGE					
– VEHICLE	1	2	1	2	0
– CHEM PROP (STME)	2	2	2	1	0
● MARS DEPARTURE STG					
– VEHICLE	1	1	1	2	0
– CHEM PROP (RL100)	2	1	1	2	0
● EARTH BRAKING STAGE					
– VEHICLE	1	1	1	1	0
– CHEM PROP (RL100)	2	1	1	2	0
● OTV (ASSUME EXISTING IN 1998)	~				
● STS FLIGHTS		(RESERVE	5 FLIGHTS)		



TEST AND TRAINING UNIT DELIVERIES PRECEDE THE FLIGHT UNIT DELIVERIES SHOWN ABOVE.

FIGURE 2

MANNED MARS MISSION SPACECRAFT

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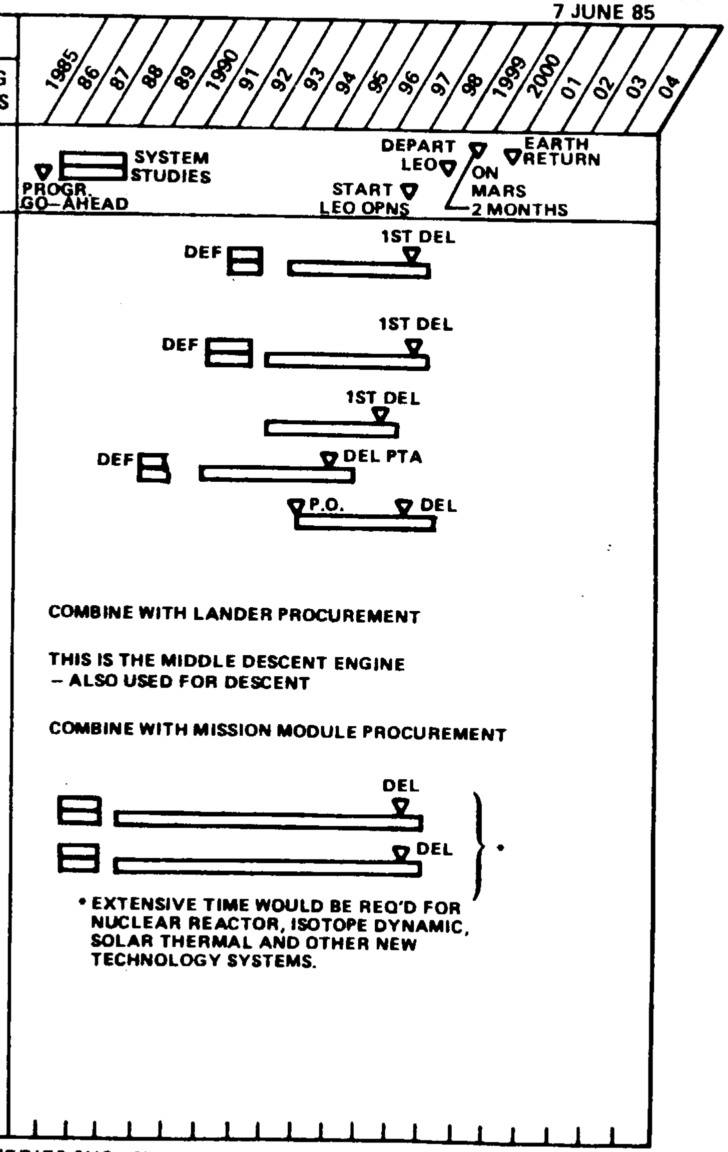
MAJOR HARDWARE ELEMENTS	HWD. QUANTITY: FLIGHT UNITS	GSE SETS	SOFT-WARE SETS	TESTS UNITS	TRNG UNITS
MAJOR MILESTONES					
● MARS MISSION MODULE	1	1	2	1	2
● MARS EXCURSION MODULE (MEM)					
– LANDER	1	1	2	2	2
● DEORBIT PROPUL. (EXIST STAR 30B)	7	2	0	3	0
● DESCENT PROPUL.	2	2	3	2	0
● MODULE AND AEROBRAKE SHIELD	1	1	0	0	0
– ASCENT					
● MODULE	1	1	2	2	2
● ASCENT PROPUL.	1	~	~	~	~
● INTEGR. SPACECRAFT VEH.	1	1	1	1	1
– POWER SUBSYSTEM					
● MISSION MODULE	1	1	2	1	0
● MARS EXCURSION MODULE	1	1	2	1	0



TEST AND TRAINING UNIT DELIVERIES PRECEDE THE FLIGHT UNIT DELIVERIES SHOWN ABOVE.

FIGURE 3

MANNED MARS MISSION
SDV–3R PAYLOAD ADAPTERS

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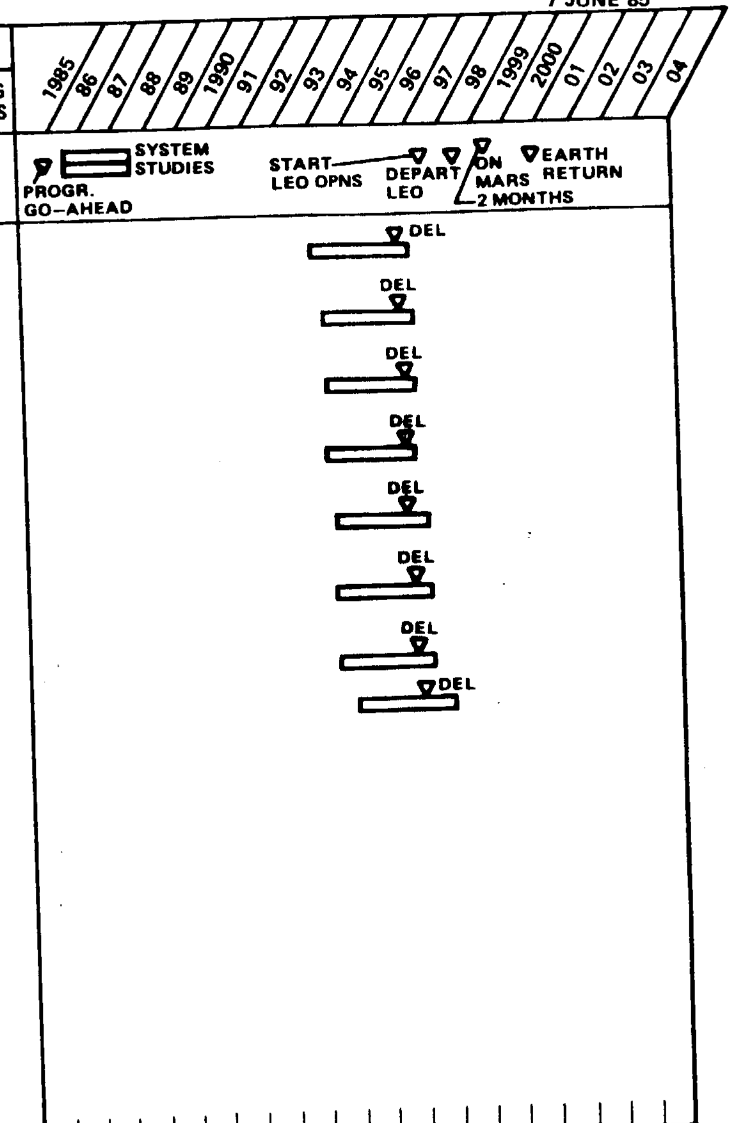
MAJOR HARDWARE ELEMENTS	QUANTITY: FLIGHT UNITS	GSE SETS	SOFT-WARE SETS	TESTS UNITS	TRNG UNITS
MAJOR MILESTONES					
• LEO ASSY STATION EQUIP ADAPTER	4	2	0	2	0
• PROPELLANT FARM EQUIP ADAPT	6	3	0	3	0
• EARTH DEPARTURE STG ADAPT	1	1	0	1	0
• SPACECRAFT STRUCTURE ADAPT	1	1	0	1	0
• VARIOUS MODULES WITHIN S/C ADAPTER	6	3	0	3	0
• MARS DEPARTURE STG. ADAPTER	1	1	0	1	0
• EARTH BRAKING STG. ADAPT	1	1	0	1	0
• PROPELLANT TRANSFER TANKS ADAPTERS	4	1	0	2	0



TEST AND TRAINING UNIT DELIVERIES PRECEDE THE FLIGHT UNIT DELIVERIES SHOWN ABOVE.

FIGURE 4

MANNED MARS MISSION EXPERIMENTS

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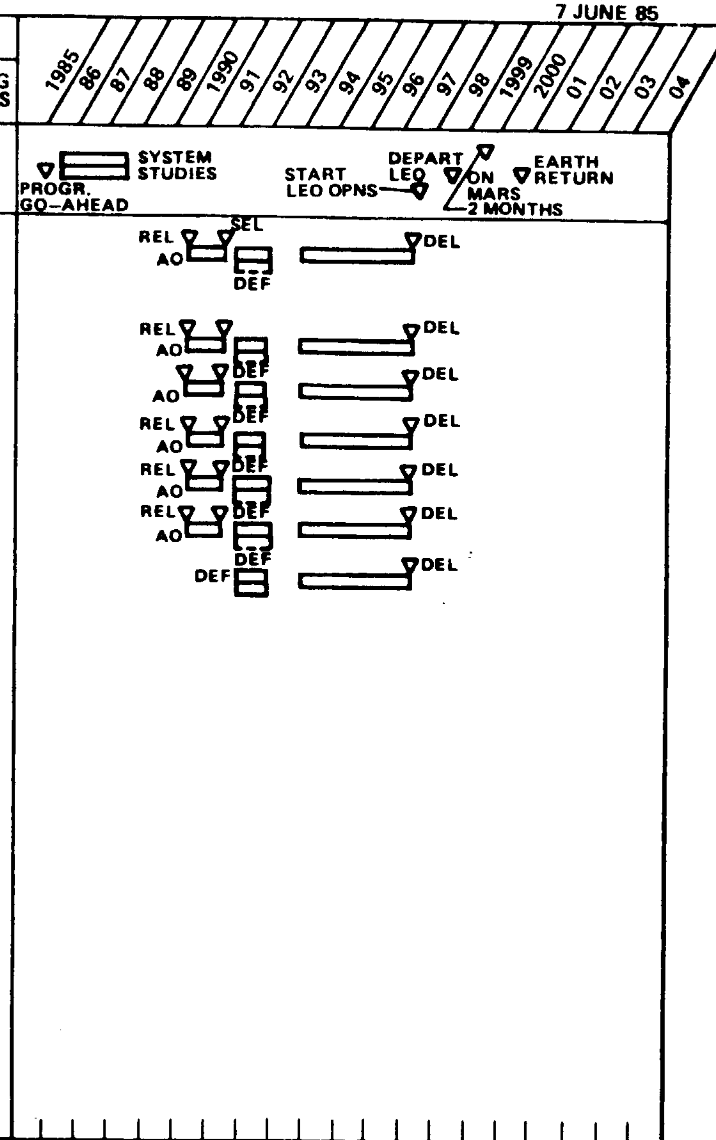
MAJOR HARDWARE ELEMENTS	HWD. QUANTITY				
	FLIGHT UNITS	GSE SETS	SOFT-WARE SETS	TESTS UNITS	TRNG UNITS
MAJOR MILESTONES					
● VENUS PROBES	4	4	8	4	0
● MARS MOON PROBES:					
– PHOBOS	2	2	4	2	0
– DIEMOS	2	2	4	2	0
● MARS PROBES	1	1	2	3	0
● MISSION MODULE EXPERI.	100	5	10	50 $\xrightarrow{\text{SOME}}$	50
● MARS SURFACE EXPERI.	100	5	10	50 $\xrightarrow{\text{SOME}}$	50
● ROVING VEHICLE	1	1	2	1 →	1



TEST AND TRAINING UNIT DELIVERIES PRECEDE THE FLIGHT UNIT DELIVERIES SHOWN ABOVE.

FIGURE 5

MANNED MARS MISSION
LEO ASSEMBLY EQUIPMENT

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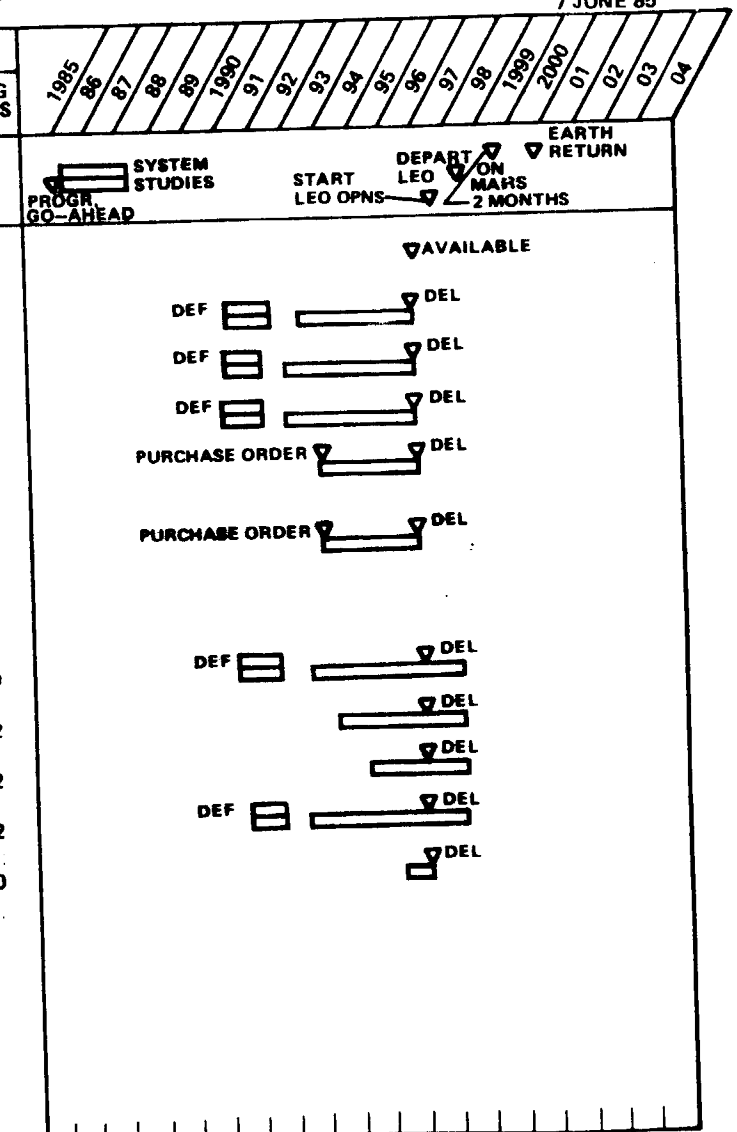
MAJOR HARDWARE ELEMENTS	HWD. QUANTITY: FLIGHT UNITS	GSE SETS	SOFT-WARE SETS	TESTS UNITS	TRNG UNITS
MAJOR MILESTONES					
● OMV	~	~	~	~	~
● ASSEMBLY FIXTURE	1	1	0	1 →	2
● CHERRY PICKER	1	1	1	1 →	2
● CONTROL MODULE	1	1	1	1 →	2
● HABITATION MODULE (SS DEVEL)	2	2	1	0	2
● LOGISTICS MODULE (SS DEVEL)	1	1	1	0	1
● PROPELLANT FARM:					
– TANKS	2	2	0	1	0
– PUMPS	2	2	0	1 →	2
– PLUMBING	1	2	0	1 →	2
– REFRIG & CONTROL S/S	2	2	1	1 →	2
– PROPELLANTS	1.4 M LB.	INCL. IN CRYO PLANTS	0	1	0



TEST AND TRAINING UNIT DELIVERIES PRECEDE THE FLIGHT UNIT DELIVERIES SHOWN ABOVE.

FIGURE 6

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MANNED MARS MISSION
TRAINING HARDWARE AND FACILITIES

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MAJOR HARDWARE ELEMENTS	HDW. QUANTITY: HDW UNITS	GSE SETS	SOFT-WARE SETS
MAJOR MILESTONES			
● LEO ASSY STATION TRNG			
– ENGR MODEL	1	1	1
– NEUT BOUY MOCKUP	1	0	0
● SPACECRAFT TRNG			
– OVERALL SPACECRAFT			
● 1–G MOCKUP	1	1	1
● N/B MOCKUP	1	0	0
– MISSION MODULE			
● 1–G MOCKUP	1	0	0
● N/B MOCKUP	1	0	0
– MEM			
● 1–G MOCKUP	1	0	0
● N/B MOCKUP	1	0	0
● ROVING VEH ENGR MODEL	1	1	1
● EXPERIMENTS			
– N/B MOCKUPS	40	0	0
– ENGR. MODELS	40	10	20

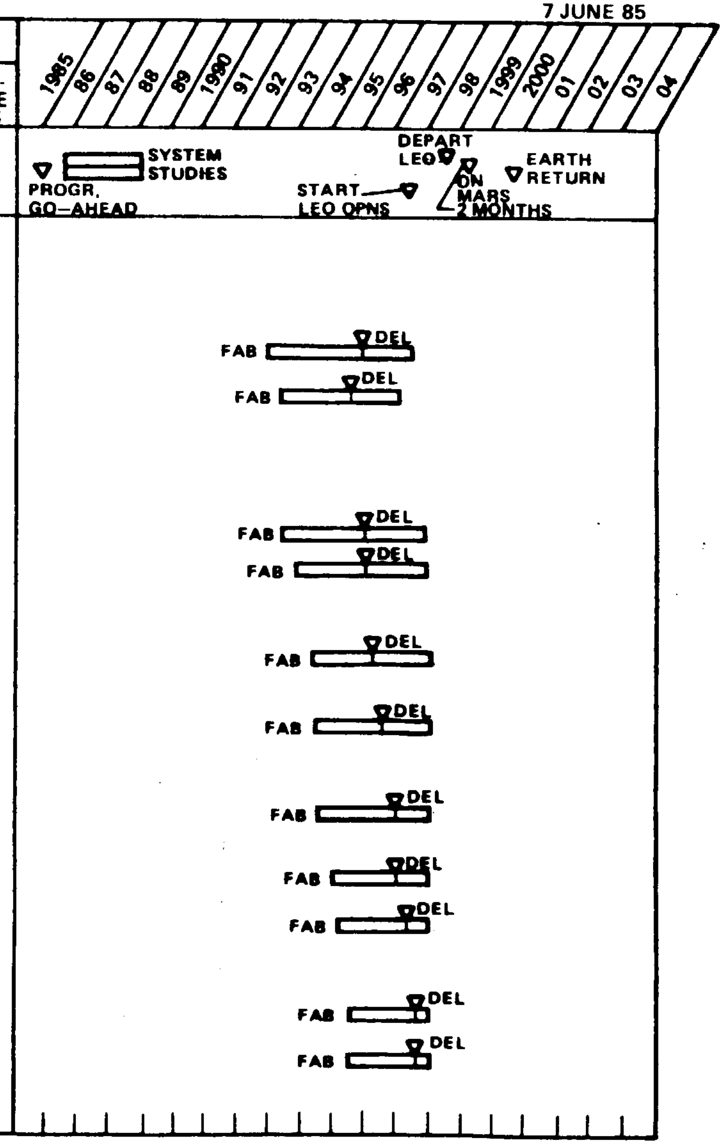

FIGURE 7

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MANNED MARS MISSION
MISSION CONTROL & COMMUNICATIONS NETWORK

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MAJOR HARDWARE ELEMENTS	HDW. QUANTITY: FACIL UNITS	GSE SETS	SOFT–WARE SETS	TESTS UNITS	TRNG UNITS
MAJOR MILESTONES					
● MISSION CONTROL CENTER	1	1	3	0	0
● COMMUNICATIONS NET					
– LEO OPERATIONS; 2ND GENERATION TDRS (ASSUME EXISTS BY 1996)	2	1	1	0	0
– DEEP SPACE; MODIFY JPL NETWORK	1	1	1	0	0

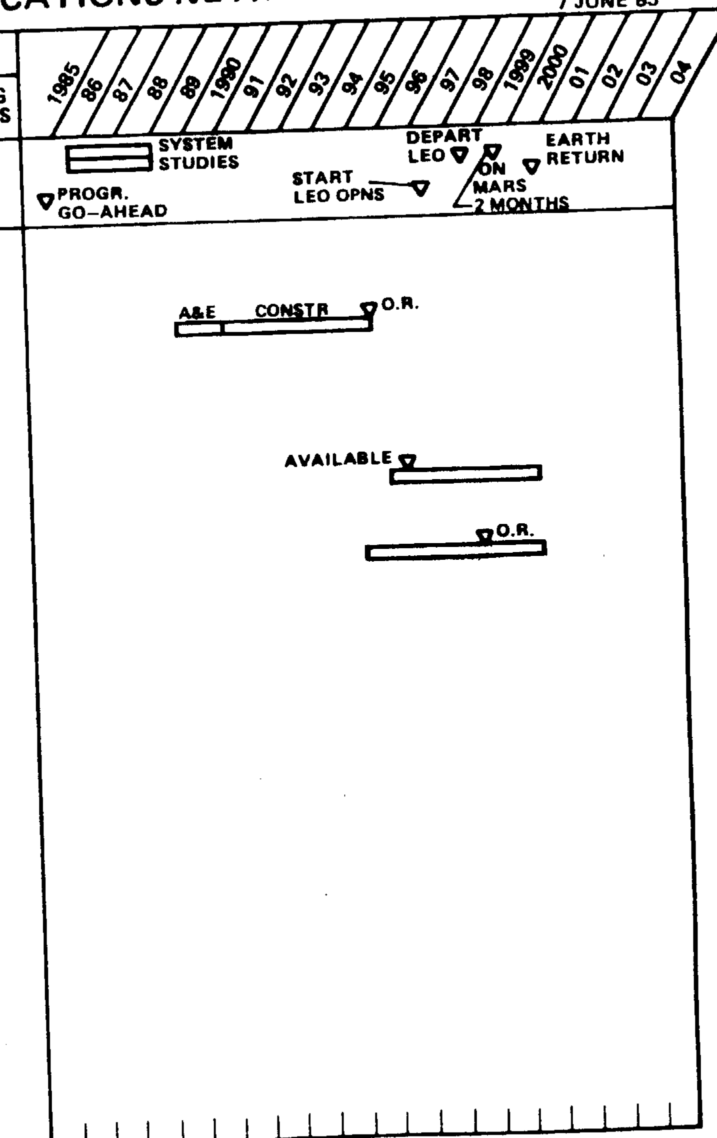

FIGURE 8

accomplished away from the Space Station, a control module will serve as a work station for the astronauts. It is anticipated that a multitude of operations will be required. These operations may utilize mechanized arms, robotics, and the OMV, and will require extensive EVA activities. The mission modules could serve as the habitation module for the astronauts during the assembly period.

Experiment operations could begin in LEO during assembly operations and continue until Earth return.

Extensive training hardware will be required for the manned Mars mission. In each applicable category of hardware, test and training unit deliveries will precede the flight unit deliveries.

ASSUMPTIONS

- o No test flights are planned prior to a manned landing.
- o Optimum Mars launch windows occur on approximately 2 year intervals.
- o SDV-3R vehicle, manufacturing/test facilities and launch facilities development are not planned under this program (assume previous development).
- o All flights planned in support of the manned Mars mission are in addition to the STS Program of 24 flights per year.
- o Test and training unit deliveries precede the flight unit deliveries shown above.
- o OTV is assumed to be in existence and available by 1997 (includes aerobraking shield).
- o OMV is assumed to be in existence and available for assembly operations by 1997-98.
- o Habitation and logistics modules used for LEO assembly will be copies of then existing SS modules.
- o LEO assembly equipment is independent of existing Space Station equipment.
- o The launch vehicle SE&I contractor will also be responsible for the payload adaptors, vehicle GSE, vehicle software and vehicle integration hardware.
- o Existing neutral buoyancy facilities are adequate with judicious scheduling.

RISK ASSESSMENT

With the assumptions previously listed, the SDV-3R vehicle schedule should represent only a minimum risk. Early go-ahead is required for definition studies for the Space Transportation Main Engine (STME) for the Earth LEO departure stage and the RL100 engine for the Mars departure stage. Per previously mentioned assumptions, the OTV with its aerobraking shield and the OMV will have been developed by the time of the manned Mars mission. Early go-ahead is required for power systems for the spacecraft, particularly if nuclear or isotope systems are to be utilized.

CONCLUSION

In conclusion, it appears realistic from a schedule standpoint that a pre-2000 manned Mars mission is possible. However, it will be imperative that early go-ahead with adequate funding authorization be given so that the necessary planning and definition studies can be initiated for the long lead hardware.

TABLE 1

POWER SUBSYSTEMS

POWER SUBSYSTEM OPTIONS	DEVELOPMENT TIME
Mission Module (MM)	
o Photovoltaic	5-7 years
o Solar Thermal	10 years
o Nuclear Reactor	10 years
o Isotope Dynamic (DIPS)	10 years
o Regenerative Fuel Cell	5-7 years
Mars Excursion Module	
o Photovoltaic	5-7 years
o Solar Thermal	10 years
o Isotope Dynamic (DIPS)	10-12 years
o Open Loop Fuel Cell	5-7 years
o Nuclear Reactor	
- Multi-Hundred Watt	10 years
- General Purpose HS	10 years
- Hydride Reactors	10-12 years
- SP-100	10 years
o Laser/R-F Transmission	12 years
o Photovoltaic + Regen. Fuel Cell + Isotope	10 years
o Photovoltaic + DIPS	7-10 years
o Multi Megawatt	15 years